APPENDIX J

MAINSTEM IMPACTS ANALYSIS

Draft Environmental Impact Statement
Allocation of Water Supply and
Long-Term Contract Execution
Central Arizona Project

APPENDIX J IMPACTS TO THE COLORADO RIVER MAINSTEM DUE TO NAVAJO/HOPI CAP DIVERSIONS

Under Non-Settlement Alternatives 2 and 3, the Navajo Nation and Hopi Tribes (Navajo/Hopi) receive a combined allocation of 13,500 acre-feet annually (afa). It is anticipated that this water will be used solely for municipal and industrial (M&I) purposes and will be diverted from Lake Powell at a constant rate of less than 20 cubic feet per second (cfs). This appendix estimates the impacts of this diversion to the Colorado River mainstem.

As all other Central Arizona Project (CAP) diversions occur at Parker Dam, the flow regime of the Colorado River is potentially altered from Glen Canyon Dam to Parker Dam. Lake Mead, situated between Glen Canyon and Parker Dams, is a large regulating reservoir and would completely mask the impact of Navajo/Hopi diversions downstream of Hoover Dam. Therefore, this analysis is restricted to the reach of the Colorado River between Glen Canyon Dam and Lake Mead.

The impacts analyzed are lost power revenues at Glen Canyon Dam and the change in Colorado River water surface elevation.

J.I. VALUE OF FOREGONE ENERGY GENERATED AT GLEN CANYON DAM

One of the alternatives being considered by the Bureau of Reclamation (Reclamation) in connection with the CAP allocations is diversion of 13,500 afa from Lake Powell to serve M&I demand on the Navajo/Hopi Reservations. This section analyzes the value of the foregone energy production at Glen Canyon Dam as a result of this diversion of water.

Energy production at Glen Canyon was 6,626 gigawatt hour (GWh) in fiscal year 1998 and 6,700 GWh in fiscal year 1997. Installed generation capacity is 1,356 megawatts (MW). Actual operating capacity was 1,288 MW on July 1, 1998.[1]

During 1999, 11,706,000 acre-feet (af) of water were released at Glen Canyon Dam for power production.[2] Diversion of 13,500 af represents 0.12 percent of 1999 power releases. Forecast releases for 2000 and 2001 are less than 1999 actual releases, and the diversion would be about 0.19 percent of 2000 releases and 0.13 percent of 2001 releases. Thus, the impact of the diversion of water is likely to be small.

[1] These data are from Western Area Power Administration (WAPA), 1998 Annual Report, Statistical Appendix.

[2] Water release and reservoir elevation data for 1999 and forecasts for 2000 and 2001 are from the Reclamation: www.uc.usbr.gov/wrg/crsp/crsp_gc.txt.

In order to estimate the value of foregone energy, the following assumptions were made:

J.I.a.

The amount of power produced in a given hour at Glen Canyon is a function of lake elevation and volume of water going through the turbines measured in cfs. This function was estimated by taking six days of Glen Canyon records[3] that provide hourly MW of generation, lake elevation, and releases of water for power production. The total number of observation points is six days times 24 hours per day = 144 points. A regression analysis was estimated which indicates that in any hour, each additional cfs of water adds 0.0408 MW of power production, and each additional foot of lake elevation adds 1.24 MW of power production.[4]

J.I.b.

For ease of computation, it is assumed that power production is constant over all hours of a given month, but that power generation varies from month to month. Specifically, MW of power production in each hour of each month were estimated using the regression analysis described above, assuming that the hourly water releases equal the average water releases in that month in 1999 and that the lake elevation equals the elevation at the end of the month in 1999. Since the regression equation estimates average power production in one hour, total energy production megawatts per hour (MWh) in a month is computed by multiplying the estimated MW generated by the number of hours in the month.[5]

J.I.c.

Diversions of water are assumed to be 20 cfs continuously throughout the year.

J.I.d. Monthly MWh generation was re-estimated with the regression equation for 1999 conditions minus the continuous diversion of 20 cfs. The difference between the results from step 2 above and this analysis represents foregone energy generation. Foregone energy generation is about 7,148 MWh per year.

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[3] Hourly records are from the WAPA web site: www.wapa.gov/crsp/operatns.dir. The dates selected for the analyses were January 15, 1999, March 27, 1999, June 2, 1999, July 29, 1999, August 31, 1999, and November 29, 1999. These dates were selected to represent the range of water releases that would occur at various times of the year.

[4] The regression equation is: MW = -4569.972 + .0408cfs + 1.240E, where MW is MW of power production in a given hour, cfs is cubic feet per second of water releases during that hour, and E is elevation of the reservoir in feet at that hour. R squared = 1.0 because the analysis simply uncovers engineering relationships.

[5] The representativeness of the data and the applicability of the method were checked by comparing actual monthly MWh generation with calculated monthly MWh for 1999. The sum of the absolute values of differences between calculated and actual MWh generation is only 1.05 percent of the actual generation.

J.I.e.

Foregone energy generation may be replaced with spot market purchases plus transmission costs. These costs represent the value of foregone hydro generation at Glen Canyon.[6] Monthly spot market prices for 1999 were estimated using the Dow Jones Palo Verde Index for firm energy for on-peak and off-peak periods. It was assumed that 57 percent of the foregone generation would have occurred during on-peak hours. Transmission costs were estimated for the associated MW rounded up to the next whole MW of reserved capacity, averaged over five transmission utilities: Arizona Public Service, Salt River Project, Nevada Power Company, Tucson Electric Power Company, and Public Service Company of New Mexico.[7] Transmission service is assumed to include point-to-point service plus Ancillary Services 1 and 2 (Scheduling, System and Dispatch Service and Reactive Supply and Voltage Control from Generation Sources Service). Other Ancillary Services would typically be required only in the control areas where the load is located and were omitted from this calculation.

Under these assumptions, the value of foregone generation under 1999 conditions would have been about $226,000. To put this annual impact into perspective, in fiscal year 1998, WAPA's Salt Lake City Area Integrated Projects (SLCAIP) power sales were $152.5 million dollars. Glen Canyon generation was about 77 percent of SLCAIP MWh sales.[8] The value of the foregone energy generation is, thus, roughly 0.19 percent of the portion of SLCAIP revenues attributable to Glen Canyon.

The present value of 51 years of the foregone generation, assuming a real growth rate in spot market electricity prices of 2 percent per year[9] and a real growth rate in transmission service prices of 0 percent per year, is $7.8 million (in 2001 dollars) computed with a real discount rate of 3.43 percent.[10]

J.II. CALCULATION OF COLORADO RIVER WATER SURFACE ELEVATION CHANGE DUE TO NAVAJO/HOPI CAP DIVERSIONS

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[6] Strictly speaking, the value of foregone generation should be the difference between spot market prices plus transmission costs and avoided variable costs of hydropower production. It is assumed that the variable cost of hydropower production is zero.

[7] Transmission and ancillary service costs are from the utilities' Open Access Transmission Tariffs.

[8] WAPA, 1998 Annual Report, Statistical Appendix.

[9] For comparison, the Energy Information Administration, *Annual Energy Outlook 2000* provides the following annual average real growth rates in prices for the period 2001 to 2020 for the Mountain Region (Supplemental Table 18): electricity prices in the industrial sector, -0.46 percent; natural gas prices paid by electric generators, 1.80 percent; and fossil fuel prices paid by electric generators, 0.08 percent.

[10] Concomitant with the diversion of 13,500 af of water from Lake Powell, there would be less water to distribute in central Arizona, thereby lowering pumping costs along the CAP canal. The draft preliminary 2001 water rate schedule for the CAP sets forth a pumping energy rate of $29 per af. At this rate, avoided pumping costs associated with the 13,500 af of water diverted at Lake Powell would be about $392,000 per year. In addition, the Lake Powell diversion would also result in less water available for agriculture and M&I use in central Arizona and in more power (generated by power plants, which serve CAP) for sale in power markets.

Colorado River channel characteristics were taken from the *Operation of Glen Canyon Dam, Final Environmental Impact Statement.* Table J-1 shows the eleven Colorado River reaches analyzed with the channel characteristics of each. These channel characteristics were inputs to Manning's equation, which estimates a depth of flow given certain channel characteristics.

Table J-1
CAP Allocation Draft EIS
Colorado River Channel Characteristics

Reach Number	River Miles	Reach Name	Width Type	Average Channel Width (feet)	Average Depth (feet)	Channel Slope (feet per mile)	Percentage of Bed Composed of Bedrock and Boulders	Estimated Manning's n
0	-15.50-0	Glen Canyon	Wide	450	27	1.4	>80	NA
1	0-11.3	Permian Section	Wide	280	24	5.2	42	0.055
2	11.3-22.6	Supai Gorge	Narrow	210	27	7.4	81	0.055
3	22.6-36	Redwall Gorge	Narrow	220	24	7.9	72	0.055
4	36-61.5	Lower Marble Canyon	Wide	350	18	5.3	36	0.04
5	61.5-77.4	Furnace Flats	Wide	390	15	11.1	30	0.04
6	77.4-117.8	Upper Granite Gorge	Narrow	190	27	12.1	62	0.055
7	117.8-125.5	Aisles	Narrow	230	21	9.0	48	0.055
8	125.5-140	Middle Granite Gorge	Narrow	210	26	10.6	68	0.055
9	140-160	Muav Gorge	Narrow	180	23	6.3	78	0.055
10	160-213.8	Lower Canyon	Wide	310	19	6.9	32	0.04
11	213.8-236	Lower Granite Gorge	Narrow	240	30	8.4	58	0.055
12	236-278	Lake Mead	Not Applicable					

The Manning's roughness coefficient (or Manning's n)varied based on the percentage of bed composed of bedrock and boulders. The roughness coefficients were taken from the Arizona Department of Transportation's *Highway Drainage Design Manual* Hydrology for channel material composed of cobbles and boulders. The roughness coefficient for cobbles (0.04) was used for bed compositions of less than 40 percent bedrock and boulders, while the roughness coefficient for boulders (0.055) was used for bed compositions of more than 40 percent. Various river depths were inserted into Manning's equation to achieve the minimum and maximum flows of the preferred alternative as well as the diminished flows due to the Navajo/Hopi diversion.

In the *Operation of Glen Canyon Dam, Final Environmental Impact Statement,* the preferred alternative was the modified low fluctuating flow alternative. In this alternative, the minimum releases fluctuate between 5,000 cfs at night and 8,000 cfs during the day. The maximum release was 25,000 cfs. Using these minimum and maximum flows, the change in depth in the Colorado River associated with the 20 cfs diversion was calculated.

Table J-2 shows the change in depth of the Colorado River associated with the 20 cfs decrease in flows. It is assumed that the slightly lower water surface does not have a significant impact to the habitat.

TableJ-2
CAP Allocation Draft EIS
Colorado River Changes in Depth

Reach	Glen Canyon EIS Preferred Alternative Flow Regime (cfs)	Flow Regime Due to Navajo/Hopi Diversion (cfs)	Change in Depth Due to Navajo/Hopi Diversion (inches)
Reach 1 – Permian Section	5,000	4,980	0.0144
	8,000	7,980	0.0120
	25,000	24,980	0.0072
Reach 2 – Supai Gorge	5,000	4,980	0.0108
	8,000	7,980	0.0096
	25,000	24,980	0.0060
Reach 3 - Redwall Gorge	5,000	4,980	0.0144
	8,000	7,980	0.0120
	25,000	24,980	0.0072
Reach 4 - Lower Marble Canyon	5,000	4,980	0.0096
	8,000	7,980	0.0072
	25,000	24,980	0.0048
Reach 5 - Furnace Flats	5,000	4,980	0.0084
	8,000	7,980	0.0060
	25,000	24,980	0.0036
Reach 6 - Upper Granite Gorge	5,000	4,980	0.0144
	8,000	7,980	0.0120
	25,000	24,980	0.0072
Reach 7 – Aisles	5,000	4,980	0.0132
	8,000	7,980	0.0108
	25,000	24,980	0.0072
Reach 8 - Middle Granite Gorge	5,000	4,980	0.0132
	8,000	7,980	0.0108
	25,000	24,980	0.0072
Reach 9 - Muav Gorge	5,000	4,980	0.0168
	8,000	7,980	0.0156
	25,000	24,980	0.0096
Reach 10 - Lower Canyon	5,000	4,980	0.0096
	8,000	7,980	0.0084
	25,000	24,980	0.0060
Reach 11 - Lower Granite Gorge	5,000	4,980	0.0132
	8,000	7,980	0.0084
	25,000	24,980	0.0072

Based on the small decrease in water surface elevation throughout the reaches and flow regimes, the impacts to aquatic and other wildlife are considered insignificant.